

## SECTION C - ARS INDUSTRIAL HYGIENE FUNCTION

## CHAPTER V - ARS LABORATORY CHEMICAL FUME HOODS STANDARDS

### CHAPTER V

#### ARS LABORATORY CHEMICAL FUME HOODS STANDARDS

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## CHAPTER V - SECTION C

### LABORATORY CHEMICAL FUME HOODS STANDARDS

#### A PURPOSE

Public Law 91-596, Section 19, "Occupational Safety and Health Act," and Executive Order 12196, Occupational and Health Program for Federal Employees" require the establishment of safety and health programs that assures safe and healthful working conditions for all Federal employees. A method of providing such working conditions is the use of engineering controls that restrict employee

exposure through removal of the hazards from the work place. Laboratory chemical fume hoods is a type of engineering control that captures and eliminates hazards by mechanical ventilation control.

## B SUMMARY

This Chapter contains detailed standards and information for:

1 Laboratory fume hood containment.

2 Types of Chemical Fume Hoods.

3 The aerodynamics of laboratory fume hood containment.

4 Design features of laboratory fume hoods.

5 Hood exhaust systems.

6 Exhibits which include:

- o Laboratory Chemical Fume Hood Specifications and Performance Tests
- o Corrosion Resistance Chart
- o Diagram of Acceptable Stack Head Designs

## C FORM

ARS-283, Laboratory Chemical Fume Hood Inspection (for local reproduction)

## D DEFINITIONS

1 Air Vector - The direction of air flow.

2 Back Baffle - A rear partition which usually has two adjustable slots and one fixed slot.

3 Bypass - The opening which allows air to enter the hood when the sash is closed.

#### D DEFINITIONS (Continued)

4 Face Opening of Hood - The opening bounded by the two side airfoils, countertop, and the bottom of the sash (when measurements are taken).

5 Face Velocity - The velocity of air (in feet per minute-fpm) passing through the face of the hood.

6 Plenum - A pressure equalizing chamber.

7 Pulsing - Frequent movement of air in different directions; as opposed to a steady state or linear flow condition.

8 Rolling Effect - The movement of air in the top section of the hood which rolls around above the bottom of the sash when the sash is in a raised position.

9 Short Term Exposure Limit (STEL) - The maximal concentration to which workers can be exposed for a period up to 15 minutes continuously without suffering from (1) irritation; (2) chronic or irreversible tissue change; or (3) narcosis of sufficient degree to increase accident proneness, impair self-rescue, or materially reduce work efficiency, provided that no more than four excursions per day are permitted, with at least 60 minutes between exposure periods, and provided that the TLV-TWA also is not exceeded. The STEL should be considered a maximum allowable concentration, or ceiling, not to be exceeded at any time during the 15 minute excursion period.

10 Threshold Limit Value - Time Weighted Average (TLV-TWA) - The time-weighted average concentration for a normal 8-hour workday and a 40-hour work week, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.

11 Threshold Limit Value-Ceiling (TLV-C) - The concentration that should not be exceeded even instantaneously.

12 Uranine - Sodium fluorescein.

## E GUIDELINES

1 Laboratory Fume Hood Containment - General.

a The purpose of a laboratory fume hood is to protect the operator from exposure to hazardous chemicals by preventing or minimizing the escape of contaminants into the laboratory. This is

#### E GUIDELINES (Continued)

accomplished by drawing air from the laboratory, past the operator, into the hood. The concentration of the contaminant in the actual breathing zone of the operator must be kept as low as possible and must never exceed the applicable TLV-TWA for the materials in question. Since the laboratory worker is seldom stationed at the hood for long periods of time (periods approaching 8-hours duration), the

STEL, the TLV-C, or the peak value as proposed in the American Conference of Governmental Industrial Hygienist listing of TLV's shall be used whenever possible in assessing permissible worker exposure levels. Where no STEL or TLV-C has been proposed, the ACGIH suggested excursion factor shall be applied to the TLV proposed as a time weighted average. The use of TLV's alone to decide the type of hood and the air velocities required for control is discouraged. For materials of unknown toxicity or where specific toxicity data is not available, a system based on the ratio of the compound vapor pressure/assumed TLV" selected on the basis of the TLV for a similar compound is the method of choice for providing the best indication of the potential hazard.

NOTE: "Threshold Limit Values and Biological Exposure Indices" is a handbook published by the ACGIH. It is available for purchase from:

American Conference of Governmental

Industrial Hygienists, Inc.

6500 Glenway Ave., Building D-7

Cincinnati, Ohio 45211

Phone: (513) 661-7881



b In every event, it is the actual exposure outside of the hood that is the critical factor. Assistance for the determination of the above parameters is available through:

Safety, Health, and Environmental

Management Branch

Facilities Division

6303 Ivy Lane

Greenbelt, Maryland 20770

ATTN: Industrial Hygienist

Comm: (301) 436-6475

E GUIDELINES (Continued)

c The ability of a laboratory hood to provide adequate protection for the user, within the exposure limits noted above, depends on many factors. Prime concerns include:

- (1) Air movement and flow patterns in the room.
- (2) Turbulence within the hood work space.
- (3) The effect of the operator on the air flow pattern at the hood face.
- (4) The control velocity at the hood face.

These factors must be considered as a group if the hazard control performance of the hood is to be effectively determined.

## 2 Types of Chemical Fume Hoods.

The following types of chemical fume hoods are presented for informational purposes with minimal comment as to specific advantages, disadvantages, or performance characteristics. Any hood design encountered may be the result of a combination of the following types.

a "Standard" or "Conventional" Hood.

This hood consists of an enclosure having three sides and a vertically sliding sash in front. It is equipped with a rear panel or baffle for the adjustment of air flow. The exhaust duct is connected to an exhaust plenum located between the baffle and the back wall of the hood. The fan draws 100 percent room air through the sash opening, through the baffle slots, plenum, and ductwork to the outside atmosphere. As the sash is lowered from the fully opened position, the face velocity increases in an approximate inverse proportion to the face area. A variation of the standard hood attempts to

conserve room air during lowered sash operation. A two-speed fan, operated by a microswitch, tripped when the sash is lowered to within a certain level above the work surface, cuts back to reduce the amount of room air exhausted and achieves a more constant face velocity over the range of sash positions. This approach is acceptable as long as minimum capture, slot, and transport velocities are maintained.

E GUIDELINES (Continued)

b "Balanced Air" or "Bypass" Hood

The high face velocity air stream created when the standard hood sash is lowered may cause problems such as excessive turbulence or disruption of operations within the hood. These problems may be overcome by the provision of an inlet for room air to be drawn through a bypass directly into the hood as the sash is lowered. With the sash fully open, the bypass is closed and inoperative. The quantity of air admitted to the hood through the bypass increases as the sash is lowered, but the combined volume through it and the face opening of the hood remain constant. The face velocity and the quantity of air exhausted from the laboratory are relatively constant, thus avoiding variable loads on ventilation or air

conditioning systems.

c "Auxiliary Air" or "Supplied Air" Hoods

Air conditioning of laboratory buildings and rooms requires refrigerating capacity not only to compensate for heat gain through the walls of the building and the heat load generated in laboratory processes, but also sufficient for a flow of supply air equivalent to that exhausted by all hoods in the space. Correlations between fume hood exhaust and air conditioning refrigeration have been made. Each 1,000 CFM exhausted equals approximately 3-5 tons of refrigeration system capacity. For this reason, auxiliary supply hoods have been designed to supply outside unconditioned air as a percentage of the air exhausted by the hood. While twice as much hood ductwork is required, the additional cost may be offset by the energy savings. These comparative savings continue to accrue as energy costs increase. In no instance, however, is there justification to compromise the hood performance or the intrinsic

safety of a system in the name of

energy efficiency.

The following sections discuss two concepts of auxiliary air-supplied hoods.

d "Internally Supplied" Auxiliary Supply Hoods

The internally supplied hood supplies outside unconditioned air behind the sash, directly into the hood interior. The face velocity through the face opening of the hood is thus drastically

## E GUIDELINES (Continued)

reduced, and the hood cannot prevent leakage or outfall of contaminants into the room. Internally supplied hoods do not save any room air, they merely increase the capacity requirements of the exhaust system in order to maintain adequate face velocity and contaminant control. Reductions in face velocity may result from a number of factors, such as building system imbalance, hood supply and exhaust imbalance with increased percentage of supplied air, or as a result of improper original installation.

For these reasons, auxiliary air shall never be introduced directly into the hood. These systems may, in fact, be worse than useless.

### e "Externally Supplied" Auxiliary Air Hoods.

Systems supplying air to the outside of a hood have a theoretical superiority. This superiority is, however, conditional upon the following requirements:

- (1) All or most of the supplied air must reach the hood face.
- (2) Adequate uniform face velocity must be maintained.

(3) No excessive turbulence can be tolerated at the hood face or hood interior.

Designs that do not meet these requirements must be avoided.

Generally, the most effective system available provides a horizontal supply located above the face of the hood which directs air downward at a moderate velocity until it is captured in the

air stream entering the hood face. Test methods that involve the introduction of a known amount of tracer into the supply stream and measurement of the concentration in the hood exhaust are available. Details of these methods are contained in Exhibit 1.

Auxiliary air hoods must be provided with a bypass to direct the supplied air into the hood when the sash is closed to facilitate the air conditioning system balance and control the face velocity increases as the sash is lowered.

E GUIDELINES (Continued)

f Perchloric Acid Hood.

The perchloric acid hood is a special adaptation of the standard or the auxiliary air hood for particular use with perchloric acid or other dangerous oxidizers. These hoods are equipped with water or steam sprays along the entire length of the exhaust duct and in the space between the baffle and the back wall of the hood. The sprays are operated periodically or after each use to wash down acid crystals and organic materials that may have accumulated. Receiving drains are built into the hood for the wash water. The inside surface of the hood is usually hosed down or washed by hand.

Due to the extremely hazardous and explosive nature of perchloric acid in combination with organic matter, the ACGIH lists the following recommendations for perchloric acid hoods:

(1) Do not use any other material, especially organic materials, in a hood designed specifically for perchloric acid. Do not use perchloric acid in a hood designed for other purposes. Identify perchloric acid hoods with large warning signs.

(2) Locate all utility controls on the outside of the hood.

(3) Materials of construction for this type of hood and ductwork must be nonreactive, acid resistant, and relatively impervious. Stainless steel, type 316 with welded joints, is preferred. Unplasticized polyvinyl chloride or an inorganic ceramic coating such as porcelain are acceptable.

(4) Ease of cleanliness is paramount. Use all-welded construction or impermeable inorganic sealants for joints with accessible rounded corners.

(5) The work surface should be water tight with a minimum of 1/2 inch raised front and sides, and an integral trough at the rear to collect the wash-down water.

(6) Design wash-down facilities into the hood and ductwork. Use daily or following each use to thoroughly clean perchloric acid from the exhaust system surfaces.

#### E GUIDELINES (Continued)

(7) Each perchloric acid hood must have an individual exhaust system. Avoid horizontal runs and sharp turns in the ductwork.

(8) Construct the hood and ductwork to allow for easy visual inspection of hidden surfaces.

(9) Consider the use of a high efficiency (greater than 80 percent) wet collector constructed for perchloric acid service. Locate as close to the hood as possible to minimize the accumulation of perchloric acid in the exhaust duct.

(10) Use only an acid resistant metallic fan, a metallic fan protected by an inorganic coating, or an air ejector.



- (11) Lubricate the fan with a fluorocarbon type grease.
- (12) Locate the fan outside of the building.
- (13) Use the stackhead design designated in this MANUAL.

g Radioactive Hoods.

Hoods for radioactive materials are usually variations of standard or auxiliary hoods specially constructed to permit easy cleaning such as stainless steel. They are usually equipped with High Efficiency Particulate Air (HEPA) and/or activated charcoal filters in the

exhaust ductwork on top of the hood to collect radioactive particulate matter.

Glove boxes with disposable charcoal filter cartridges are also available from commercial sources. The HEPA filters and the cartridges must be disposed of properly with other secured radioactive wastes generated by the facility.

### 3 Laboratory Fume Hood Containment - Aerodynamics.

#### a Required Face Velocities.

Face velocities of 80-100 fpm will provide adequate containment of laboratory contaminants, if the overall installation can be rated as

#### E GUIDELINES (Continued)

"good" in reference to the other listed performance factors (see b and c below). Control velocities must overcome the particle kinetics of aerosols, the molecular diffusion of gases and vapors, and all other "normal" activities which take place inside and outside of the hood. The vector of the air at the face of the hood must be inward and perpendicular to the face. Flows lower than 80 fpm do not provide the safety factors desired for normal conditions such as operator movements. Flows higher than 100 fpm are not required for "good" laboratory arrangements and do not improve performance for poor arrangements.

#### b Operator Effect.

The turbulent air patterns resulting from the passage of makeup air around an operator standing in front of a hood, have tremendous effects on the air flow characteristics. Serious losses of contaminants from the hood can occur unless the low pressure area in front of the operator is minimized via the proper use of makeup air and the assurance of sufficient capture velocity at the face of the hood.

c Air Movement in the Laboratory.

The effect of air movement within the laboratory on the performance of hoods is directly related to hood location and the influence of air supply systems. Hood locations must be away from doors, windows, and pedestrian traffic. Air from these sources can have velocities several

orders of magnitude greater than the hood face

velocity, creating the potential for dragout or displacement of contaminated air from the hood. Air from outlets, such as ceiling and/or wall diffusers, must either be controlled to assist in the performance of the hood or directed so that the energy is lost before entering the zone of influence. Air from the makeup systems should not exceed 20-25 fpm in the hood face area (measured with the hood exhaust "off"). If these criteria are judged satisfactory, the system then can be considered "good" and the required face velocities of 80-100 fpm are valid.

E GUIDELINES (Continued)

d Hood Turbulence.

As air enters the hood, it is drawn past equipment and sources of contamination toward the exhaust slots. At airflows greater than needed to provide a good vector and containment, excessive turbulence can cause a "rolling effect" in the hood chamber. This increases the potential for greater mixing of contaminated air and room air at the face of the hood. Under poor laboratory hood arrangements, greater turbulence can result in excessive spill-out of contaminated air into the room. For this reason, it is obvious that substandard hood operations cannot be upgraded merely by increasing air flow.

#### e Modification and Repair.

Modification and repair of existing fume hood systems, with the purpose of improving performance, should generally follow these steps:

- (1) Assess the present operating characteristics of the hood system.
- (2) Determine whether repairs are needed due to damage or deterioration.
- (3) Determine whether appropriate modifications to the fume hood proper can be made to improve containment characteristics.
- (4) Determine whether modifications to the duct system can be appropriately made to lower the static pressure requirement of the exhaust system.

(5) After other methods to improve hood performance have been tried, calculate a new fan speed and horsepower, or change the fan assembly to increase CFM to required level.

#### 4 Design Features of Laboratory Fume Hoods.

##### a Special Applications.

Special applications requiring extensions of general chemical fume hood design features are feasible in certain instances. They are not

#### E GUIDELINES (Continued)

exempted from the requirements set forth in this MANUAL.

##### b New Installations.

Because the laboratory hood is part of an overall system involving the laboratory, the duct system, the fan, and, in certain circumstances, effluent cleaning devices, it is essential that each portion of the

system be chosen carefully. Performance criteria must be specified and satisfied. The laboratory hood manufacturer shall provide proof that the unit performs satisfactorily under the conditions required. Materials must meet specified corrosion resistance standards, fans must be rated by the Air Moving and Conditioning Association (AMCA), plumbing fixtures and electrical outlets must meet existing codes, and controls should be externally located whenever possible. Actual specifications and procedures for certifying aerodynamic performance of fume hoods are included in Exhibit 1 of this MANUAL. Some major equipment manufacturers can perform these tests, and the services of independent testing laboratories are also available. The performance of such tests is required when new systems are purchased. When new installations are constructed, careful planning and placement in reference to room air supplies can provide the maximum operator protection with the minimum quantity of air movement.

c Existing Laboratories.

If room conditions and air supplies are not conducive to nonturbulent hood operations, increasing face velocities will not provide satisfactory containment. Room modifications must first be made to provide for air flow into the hood to be less than 20 fpm (with the hood exhaust "off").

Satisfaction of this criterion means that "good" conditions prevail. When "good" conditions are established, 100 fpm shall be used as the design control velocity determined by the means provided in Exhibit 1. To assure continued satisfactory performance, all laboratory hoods should be inspected. The initial survey should be sufficiently extensive to properly rate the overall performance and provide a valid baseline for followup inspections. All hoods should be

E\_\_\_GUIDELINES (Continued)

inspected at least annually. If filters and dampers (or any other special applications) are involved, the inspection should be made at least on a quarterly basis.

## 5 Hood Exhaust Systems.

Unless specially approved by the Safety and Health Policy Staff, Facilities Division, individual exhaust systems must be provided for each fume hood. Manifolding of up to four hoods may be considered. Generally, the combining of systems beyond this is strongly discouraged because it increases the potential for many additional problems such as: difficulty in air balancing, loss of control at numerous sites in the event of fan failure, corrosive actions, interference with work of many operators during servicing or performing minor repairs on the system, reduced potential for adding effluent cleaning devices in the future, and the possible undesirable interaction of effluents. It is recognized, however, that certain design situations may not accommodate individual exhaust and will have to be evaluated on a case-by-case basis. A nighttime reduction in exhaust may also be considered during unoccupied hours as a means of conserving energy.

Supply air duct systems within the building can serve multiple labs or hoods if their design incorporates the necessary air volume requirements

to assure hazard control ventilation is not interfered with.

Duct material can vary, but long life, corrosion resistance, and accessibility for replacement are factors that must be considered. A chart of corrosion resistance characteristics can be obtained from your servicing ASHM.

Fans must be AMCA rated, and must be installed at the end of each duct system so that all ducts within the building are maintained under negative pressure. Fan discharges should be angular-up into a vertical offset stack, as shown in the ACGIH Industrial Ventilation Manual illustration attached in Appendix III, and the stack should extend well above the roof eddy zone. Generally, stacks should extend at least 10-feet above the roof level of one-story buildings and 15-feet above the roof level.

Discharge should be directed upward at a velocity of at least 2,500 fpm to minimize chances of recirculation.

## E\_\_GUIDELINES (Continued)

Asthetic objections may be overcome by architectural consideration for the release of contaminants in the design stages of a structure. Incorporating an exhaust tower or a cluster of exhaust stacks may be made an element of the building. The bunching of exhaust stacks has the added advantage of creating a mass of exhausted gases which is less readily deflected from upward vertical flow by wind gusts. A further, although very costly, alternative is to provide for remote discharge or inlet supply locations.

The use of cone-style weather caps is prohibited. Any accumulation of rainwater in the approved stackheads can be minimized by the removal of the plug on the fan scroll. Fresh air inlets for the building supply systems should be displaced as far as possible from the exhaust discharge.

## F EXHIBITS

### 1 Laboratory Chemical Fume Hood Specifications

#### EXHIBIT 1



## Laboratory Chemical Fume Hood Specifications

### I GENERAL DESIGN

a All fume hoods shall be of airfoil design with radiused foil sections at the bottom and sides of the hood opening to insure maximum operating efficiency and minimum eddying of air currents. The bottom airfoil will be raised approximately one inch in order to allow air to pass under the foil and across the work surface and to serve as the terminus for vertical sliding sashes. They shall be the "bypass" type to provide a relatively constant exhaust air volume through the hood regardless of sash position.

b Horizontal sliding sashes present sharp edges to incoming air currents and produce eddies at all edges. The resultant turbulence can cause outfall of contamination. Horizontal sliding sashes are, therefore, to be avoided.

### II CONSTRUCTION

a Double wall end panels shall be provided for all fume hood superstructures, with the front of the panel at the hood opening radiused, providing a streamlined section and insuring a smooth, even flow

of air into the hood. The hood interior and panels shall be flush with the entrance shape to prevent eddy currents and back flow of air. The area between the double wall ends shall be closed to house all structural reinforcements and the sash counter-balance weight and remote control valves as are required.

b An airfoil which presents a streamlined appearance similar to the sides, shall be installed at the bottom of the hood opening. This foil shall be mounted with approximately a 1 inch open space between the foil and the top front edge of the working surface to direct an air stream across the hood work top to prevent any back flow of air at this point. The airfoil shall extend back under the sash, so that the sash closes on top of the foil, and thus does not close the approximate 1-inch opening.

c An automatic air bypass shall be furnished for the hoods at the top of the sash opening. This air bypass shall limit the maximum air velocity through the face of the hood and provide a relatively constant volume of air through the hood (regardless of sash position) when hood exhaust blower is in operation. The hood air bypass shall not be dependent on mechanical or electrical linkage, and shall be completely positive in operation. The bypass shall be located above the hood face opening, just forward of the sash when it is in the raised position. The bypass shall provide an effective

#### Exhibit 1 (Continued)

sight-tight barrier between the area outside the hood and the hood interior. The bypass shall also provide an effective barrier capable of controlling transfer of flying debris from inside the hood. The bypass shall control the increase in face velocity as the sash is lowered to attain at least twice but not more than three times design face velocity.

d A removable baffle, with one fixed nonadjustable opening and two adjustable openings - one upper

and one lower - shall be furnished at the rear of the hoods. The adjustable baffle openings are to be provided to allow the flow of air through the hood to be adjusted to compensate for types of gases, apparatus, or heat sources used in the hoods.

e Hood exteriors shall be constructed of cold-rolled steel and shall have the component parts either screwed together or fastened by button-hole fasteners to allow the removal of the end panels, front vertical fascia pieces, bypass grille, and airfoil to allow replacements or to afford access to the plumbing lines and fixtures. Spacers or reinforcements shall be welded to these main parts. After fabrication of all cold-rolled steel parts, but before final assembly, component parts shall be given an acid, alkali, and solvent resistant finish on both exterior and interior surfaces.

f Hood services shall consist of a cup drain flush with the recessed working surface and plumbing and electrical services as specified. Plumbing services shall consist of remote controlled valves located within the double wall end panels, controlled by extension rods and handles projecting through the vertical airfoils of the hood. Unless otherwise specified, the handles shall be acid resistant, nonmetallic plastic, and shall be furnished with tamper-proof and vandal resistant color coded services indexes. Valves shall be connected to panel flanges and angle serrated hose connectors located on the end panels within the hood. Interior fittings for gases and water shall be integral panel flanges and angle serrated hose connectors of acid resistant plastic, color coded to match the service. Cup drains will be positioned so as to allow direct waterflow from serrated water lines. Vertical fascia shall be punched to receive no less than four remote control service fixtures at each side of the hood. Holes not used for specific services shall be provided with removable plug buttons.

g A two-tube fluorescent light fixture (bulbs not included) of the longest practical length (up to 4 feet) shall be provided at the top of the hoods. The light fixture shall be hinged for relamping and shall be shielded from the hood interior by a tempered glass panel sealed into the hood body.

Exhibit 1 (Continued)

h A vertical sliding sash shall be provided for the hoods unless otherwise specified. Glass used in the sash shall be a minimum of 7/32" thick combination sheet. The sash shall be composed of a minimum of 18 gauge painted steel rolled shape which is mitered, welded, and ground smooth at the corners to provide a complete frame with no visible joints. Glass shall be sealed into the frame with an extruded vinyl channel. The sash shall be counterbalanced with two sash weights suspended one from each end of the sash by stainless steel cables operating over ball bearing sheaves. The sash frame shall be equipped with plastic guides, which operate in stainless steel sash guides to insure proper operation of the sash and prevent metal-to-metal contact.

i Hood interior lining shall be non-flamable, acid resistant material unless otherwise specified. The end panels, back panel, baffle and top panels shall be not less than 1/4" thick, and shall be screwed together with cleats or steel angles to form a completely rigid assembly to which the exterior cold rolled steel parts can be mounted and to prevent open spaces or joints.

j An exhaust outlet of the size specified, constructed of type 316 stainless steel (unless otherwise specified), extending 2" above the non-flamable, acid resistant material top panel, shall be provided in the top of the hood in the plenum chamber area behind the upper sloping baffle. The rectangular exhaust outlet shall be sized for approximately 1700 fpm air velocity based upon a design hood face velocity of 100 fpm.

k A sash enclosure shall be provided at the top of the hood to receive the vertical sliding sash when it is in the up position. The sash enclosure shall contain two removable panels - one each on the front and rear surfaces for access to the fluorescent lighting fixture for relamping and cleaning. If project specifications require internal wiring to a central junction box, access to the junction box shall be through removable, gasketed panels.

l Removable, flush, non-flamable, acid resistant material panels shall be provided in both interior end panels to provide access to service piping and valves to facilitate installation and maintenance.

m Partial end panels, removable, shall be provided at the exterior ends of hoods to facilitate piping, wiring, and installation.

n Electrical switch(es), receptacle(s), and built in ground fault interrupters, shall be provided per schedules for the project or as specified elsewhere.

#### Exhibit 1 (Continued)

o Hood working surface shall be type 316 stainless steel and shall be of the recessed (dished) type with a 3/8" raised lip along all four edges (to contain spills) and a uniform edge thickness of 1 1/2 ". An integrally welded type 316 stainless steel 3x6 cup sink, located near one of the rear corner, should also be installed in the work surface.

### III DIMENSIONS:

a The superstructure outside dimensions for bench mounted fume hoods shall not exceed 78" in height, 45" in depth, 48", 72", or 96" in length as selected.

b Interior clear working height shall not be less than 47" for the interior of the hood as measured from the work surface.

c The sash opening including space below bottom air foil shall be not less than 32" in height.

#### IV PERFORMANCE TESTING - GENERAL REQUIREMENTS :

a The fume hood, when properly installed in a laboratory and connected to an exhaust fan of the proper capacity, shall contain and remove fumes generated within the hood. The face velocity range shall be between 80-100 fpm as selected. The hood shall operate efficiently at any setting within this range. Hood design shall be such that it will exhaust light or heavy gases efficiently when the hood is used for ordinary laboratory work in a room free from cross drafts and without high thermal loads or other special conditions of this nature. No reverse flows of air will be allowed along the sides, top, bottom, or front of the hood. All tests shall be conducted prior to acceptance of newly installed hoods. The owner and/or a designated representative shall view the tests and successful compliance results are contingent upon concurrence by the owner and/or the representative. Failure to meet the performance requirements may be cause for rejection of the supplier.

b The performance test requirements listed in this section are also applicable for the establishment of

baseline performance characteristics for comparison with periodic evaluations of existing laboratory chemical fume hoods.

c The following instrumentation, equipment, and supplies shall be on hand for use in the performance tests:

1. Alnor "Velometer" or approved equal, direct reading, with graduations from 0-350 feet/minute.

Exhibit 1 (Continued)

2. Pitot tube and inclined manometer with graduations no greater than 0.02".

3. One-half minute smoke bombs (3 dozen).

4. Ventilation Test Kit (Drager Air Current Kit or Mine Safety Appliances (MSA) ventilation smoke tube assembly).

## V PERFORMANCE TEST PROCEDURES :

a "Properly installed" means that the hood shall be installed in an area where there is at least 5 feet clear space in front for observation of the airflow pattern entering the hood. This area shall be without cross drafts or other air currents exceeding 20 fpm that would affect the hood performance in the area in front and around the hood.

b Fume hood face velocities shall be verified as follows: with exhaust fan on, the quantity of air being exhausted shall be determined by measuring the velocity of air entering the hood face and multiplying this velocity by the square feet of hood opening. The hood sash shall be in the fully raised position. The air velocity shall be determined by averaging at least nine velocity readings taken at the hood face. Readings shall be taken in the center of a grid made up of 3 sections across the middle of the hood face and 3 sections each across the bottom and top of the hood face. Readings shall not vary more than  $\pm$  10 fpm from the average face velocity.

c When the selected face velocity has been established, the following tests shall be made:

1 Make a complete traverse of the hood face with smoke from a smoke tube to demonstrate a positive flow of air is maintained into the hood over the entire hood face. No reverse air flows or dead air space shall be permitted.

2 Use smoke from the smoke tube along each end and across the working surface of the hood, in a line parallel with the hood face and 6" back into the hood to demonstrate that no back flows of air exist at



these points. The flow of smoke shall be directly to the rear of the hood without swirling turbulence or reverse flows.

3 A smoke bomb (one-half minute size shall be discharged within the hood area to show the exhaust capability of the hood and its design efficiency. No reverse air flows will be permitted. Place lighted bomb in the hood area and move it to various places, meanwhile checking end panels and working surface to verify that no reverse air flows exist at any point. Lower the sash to closed position to

#### Exhibit 1 (Continued)

verify that a sufficient air volume is flowing through the

hood working area to carry away fumes from a massive fume source. Immediately after the smoke bomb stops discharging smoke, the hood area shall be purged of smoke.

d Lower sash to a point 6 inches above work surface. Velocity, as measured at three points across the reduced face opening, shall be at least two times but less than three times the design face velocity when the sash was fully raised.

e With the sash still at the lowered position, the exhaust air volume (indicated as a function of the average velocity determined in the duct with the pitot tube) shall be essentially the same as when the sash was fully raised. Now lower sash to fully closed position and measure exhaust flow. Total exhaust flow shall be essentially as measured previously with the different sash opening positions.

f Check sash operation by raising and lowering sash. Sash shall glide smoothly and freely, and hold at any height without creeping, assuring proper counterbalance. No metal-to-metal contact shall be

allowed between the sash and the sash tract.

## VI AUXILIARY FUME HOODS

The design features, construction, and dimensions for the auxiliary air supplied hood are the same as the specifications listed above, but the performance testing includes some additional requirements as listed below:

a The auxiliary air plenum is connected to a bypass hood which has been shown, by the standards listed above, to be functioning in an acceptable manner. No cutting or removal of exhaust duct work shall be permitted.

b Raise the hood sash and verify that the sash does not enter the auxiliary chamber and that there is no appreciable opening or means by which auxiliary air can enter hood either behind the sash or through the bypass until the sash is lowered to the point of bypass opening.

c With the exhaust system off, turn on auxiliary air system and adjust the supply air volume to 70 percent of the exhaust air volume. The supply air volume shall be determined with the pitot tube.

d Measure the air velocity along a line 3" out from the face of the hood and at a height equal to the

bottom of the sash when the sash is in a fully raised position. The velocity should not exceed 200 fpm along this line.

#### Exhibit 1 (Continued)

e Turn on the exhaust system and operate at an average face velocity of 100 fpm. Maintain supply air operation as outlined in paragraph c. This will provide a 70-30 ratio of auxiliary air to room air being exhausted by the hood.

f Again, traverse the hood face (sash fully raised) with smoke from a smoke tube. The smoke pattern shall show air flowing into the hood and that no back flow exists.

g Smoke along the sides and working surface 6" back from the hood face. All air flow shall be toward rear of hood with no back flow permitted.

h Introduce a 1-minute smoke bomb into the auxiliary air system prior to the point that air enters the plenum and observe the air pattern. Smoke must indicate a smooth uniform air pattern leaving the auxiliary air discharge and smoke must be efficiently entrained and exhausted by the hood when the sash is fully raised.

i Repeat smoke bomb test as in Section V, paragraph 3, but with the sash in fully closed position. Smoke must be efficiently captured by air entering the bypass.

## VII PERFORMANCE TEST PROCEDURES : (New Installation of Auxiliary

Air Supply Hood)

The following specialized tests are strongly encouraged as part of the certification procedures to be performed by the supplier of a new hood installation. When specified, all tests shall be conducted prior to acceptance and the results are contingent upon concurrence by the owner and/or a representative. Failure to meet these performance requirements may be cause for rejection of the supplier.

Test materials and equipment shall be provided by the manufacturer at his/her own expense.

The materials, instrumentation, and equipment required shall include:

11 - #40 DeVilbiss Nebulizers.

1 - Liter of 5 percent sodium carbonate solution.

50 - cc. of 5-10 percent uranine in 5 percent sodium carbonate solution.

- 3 - Gelman 47mm filter holders (closed) or equivalent.
- 1 - Box 47 mm Gelman glass fiber filters type A or equivalent.
- 3 - Glass probes (for sampling in exhaust duct).
- 1 - Vacuum pump (Gelman Little Giant model or equivalent).
- 1 - Source of compressed air.

Exhibit 1 (Continued)

- 1 - Mercury manometer (0-25" Hg.).
- 1 - Flowmeter (Rotameter) for flow rates of 2-10 liters per minute.
- 3 - Settling flasks (5 liter capacity or larger).
- 1 - Filter flask (aspirator type).
- 3 - Limiting orifices for sampling lines (6 liters/min.).
- 3 - Filter funnels.
- 1 - Box Whatman #41 filter paper (11 cm. size).
- 1 - Turner fluorimeter, or equivalent, with proper filters and cuvettes.

a Demonstrate that under the 70 percent auxiliary air supply condition, that capture of auxiliary air is at least 95 percent efficient. Use the uranine dye test. Details of the test are described in Section VIII.

b Demonstrate that, under conditions wherein exhaust and supply air volumes are equal, the loss of contaminated air from hood is less than 0.5 percent Tests shall be as prescribed in Section IX.

c Repeat tests in paragraphs a and b but with auxiliary air temperature maintained at 20F higher than the room air temperature.

#### VIII URANINE DYE TEST FOR ENTRAINMENT:

##### a Generation of Fine Uranine Aerosol

1 Place approximately 8 cc of 5 to 10 percent uranine solution into each of two nebulizers.

2 Set up the two nebulizers in parallel; connect air hose from compressed air source and provide access for the mercury manometer in the air line (for pressure reading).

[http://imagepc/fd/shemb\\_tools/manual230\\_93ver/C\\_ARSLaboratoryChemicalFumeHoo](http://imagepc/fd/shemb_tools/manual230_93ver/C_ARSLaboratoryChemicalFumeHoo)

1 Place a three-holed rubber stopper in the filter flask and connect the vacuum pump to the aspirator leg of the flask.

2 Place glass fiber filters in the filter holders (check for tightness).

3 Place limiting orifices on outlet side of the filter holders and connect them to holes in the stopper of the filter flask. (Now all samples are manifolded and will sample simultaneously when pump is turned on).

4 Turn pump on and check airflow through each sampler using the rotameter. All flows must be identical. (Actual flow not critical provided each sampler has same flow rate.)

5 Locate samplers in position for tests as described in sections c and d below.

6 Turn on aerosol generator.

7 Turn on sampling pump.



8 Sample for 5-minutes. Then shut off aerosol generator and sampling pump.

9 Place exactly 50 ml of sodium carbonate solution in the stoppered shaking flasks.

10 Remove filters from the holders using tweezers, and using caution to prevent contamination, place each filter in a numbered shaking flask.

11 Stopper flask and shake vigorously for 3 minutes.

12 Filter a portion of the solution from each flask through separate Whatman #41 filter papers and read fluorescence in the fluorimeter.

13 Make the necessary calculations.

Exhibit 1 (Continued)

c Check the uniform dispersion of aerosol in supply air. Three simultaneous air samples shall be taken at points across the auxiliary air discharge, and these samples when analyzed must indicate that the uranine aerosol is uniformly distributed in the auxiliary air.

d Check for uniform dispersion of aerosol in exhaust air. Three air samples shall then be taken in the exhaust duct at a point as close to the hood exhaust collar as possible (not more than 4 feet from hood). These discharge samples shall also be taken simultaneously with the sampler inlets located in the same place and at the center of equal areas in the cross sectional area of the exhaust duct. These samples when taken and analyzed must indicate the uniform mixing of auxiliary air and room air.

e Actual test for percent entrainment. When it has been proven that the uranine is properly dispersed throughout the auxiliary air, and that the auxiliary air and room air are thoroughly mixed at the exhaust sampling point, the performance test shall be performed. For this test two samplers, one at the point of discharge of auxiliary air from the supply system and one at the centerline of the hood exhaust duct at the point previously checked shall be taken simultaneously. These samples when analyzed must indicate that at least 95 percent of the auxiliary air supplied is entrained and exhausted. Test to be conducted with sash in fully raised position.

## IX Evaluation Using Tracer Gas Methods

In addition to the above method of testing the performance of hoods the method of using tracer gases may be substituted. This method requires that a gas be released at a given volume inside the fume hood. Measurements are taken both inside and outside the hood. The measurements are used to calculate if any gases are released from the hood back into the room and also to calculate a rate of

release. This rate of release can be used to determine what level of protection the hood is providing the employee. Specific details are not provided in this chapter for using tracer gases, but the above has been provided as information on possible alternatives.

#### X HOOD LOSS TEST UNDER IMBALANCE CONDITIONS:

a General: The imbalance test is a simulation of a possible field condition which can be experienced when the exhaust system for an auxiliary air hood exhausts less than the proper amount of air. The reason for such reduced exhaust could be

#### Exhibit 1 (Continued)

fan belt slippage, fan blade corrosion, and other such

commonly encountered problems. To assure adequate and safe performance, the following test requires that when the exhaust air volume has been reduced to equal the supply air volume, the loss does not exceed 0.05 percent of the hood concentration.

#### b Test Procedure:

1 Set auxiliary air volume (using calibrated flow device) to 70 percent of the exhaust air volume required to provide an average face velocity of 100 fpm.

2 Set auxiliary air temperature so that it is essentially equal to room air temperature.

3 Set exhaust air volume (using calibrated flow device) the same as the auxiliary air volume in (1) above. This provides condition of essentially 100 percent supply.

4 Generate heavy concentration of uranine aerosol within the hood work area by setting up at least 9 of the #40 DeVilbiss Nebulizers filled with 10 percent uranine and each connected to a source of compressed air. Each of the nebulizers should be provided with a goose-neck attachment which deflects and impinges the aerosol generated onto the bottom of an adjacent beaker. All nebulizers and beakers should be located in a plane 6" back from the hood sash opening, and equally space in that plane.

5 Using the manifolded sampling technique as described in VIIIb, obtain the following three samples simultaneously. Sample No. 1 taken at the centerline of the hood exhaust duct (represents hood concentration). Samples No. 2 and 3 taken 6" in from each side of sash opening, 12" out from plane of sash opening and 6" below level of work surface. The sampling time to be at least sixty minutes in duration.

6 The samples shall then extracted and fluorescence determined as described in Section VIII, paragraph b, Steps 9 through 13.

7 Calculations must indicate that the hood loss under imbalance conditions does not exceed 0.05 percent of the hood concentration.